CLAIMS

1. A self-healing composite material comprising a fibre-reinforced polymeric matrix, wherein the polymeric matrix comprises a thermosetting polymer and a thermoplastic polymer that together form a solid solution.

2. A composite material according to claim 1, wherein the reinforcing fibres comprise carbon fibres.

3. A composite material according to claim 1 or 2, which comprises a laminate of two or more reinforcing fibre layers impregnated with a polymeric matrix.

4. A composite material according to any one of the preceding claims, wherein the reinforcing fibres comprise carbon fibres, glass fibres, ceramic fibres, metal fibres and metal coated reinforcing fibres, or mixtures thereof.

5. A composite material according to claim 4, wherein the reinforcing fibres are laid in the form of a mat, aligned layer or tows.

6. A composite material according to any one of the preceding claims, wherein the reinforcing fibres are laid in one or more layers and the fibres in each

layer are axially aligned.

7. A composite material according to claim 6, wherein the layers are arranged so that the axes of fibres in different layers lie at an angle to each other.

8. A composite material according to claim 7, wherein the axes of the fibres lie at an angle of from 15° to 90° to each other.

9. A composite material according to any one of the preceding claims, wherein the reinforcing fibres are present as continuous fibres or short fibres within the matrix.

10. A composite material according to any one of the preceding claims, wherein the thermosetting polymer comprises a phenolic resin, a phenol-formaldehyde resin, an amine-formaldehyde resin, a urea-formaldehyde resin, a polyester resin, a urethane resin, an epoxy resin, an epoxy-polyester resin, an acrylic resin, an acrylic-urethane resin, a fluorovinyl resin; a cyanate ester resin; a polyimide resin or any other related high temperature thermosetting resin.

11. A composite material according to claim 10, wherein the thermosetting polymer comprises an epoxy resin cured with a curing agent comprising an anhydride or an amine.

12. A composite material according to any one of the preceding claims, wherein the thermosetting polymer has a glass transition temperature Tg and the thermoplastic polymer has a fusion or flow temperature in the range Tg ±100°C.

13. A composite material according to claim 12, wherein the thermoplastic polymer has a fusion or flow temperature in the range Tg ± 50°C.

14. A composite material according to claim 12 or 13, wherein the thermoplastic polymer has a fusion or flow temperature in the range of Tg ± 10°C.

15. A composite material according to any one of the preceding claims, which comprises from 5 to 50 % by weight of the thermoplastic polymer, based upon the total weight of the polymeric matrix.

16. A composite material according to any one of the preceding claims, wherein the thermoplastic polymer is wholly miscible with the thermosetting resin.

17. A composite material according to any one of the preceding claims, wherein the thermosetting polymer is an epoxy resin and wherein the thermoplastic polymer is polybisphenol-A-co-epichlorohydrin.

18. A composite material according to any one of the preceding claims, wherein the thermoplastic polymer does not chemically react with the thermosetting

polymer at ambient temperatures.

19. A composite material according to any one of the preceding claims, wherein the thermoplastic polymer and the thermosetting polymer are selected such that the solubility parameter of the thermoplastic polymer is within $2MPa^{\frac{1}{2}}$ of that of the thermosetting polymer.

20. A composite material according to any one of the preceding claims substantially as described in the Examples.

21. A composite material substantially as hereinbefore defined.

22. A method for producing a self-healing composite material, which comprise impregnating a layer of reinforcing fibres with a polymeric matrix comprising a thermosetting polymer and a thermoplastic polymer that together form a solid solution.

23. A method according to claim 22, which comprise forming a solution of a prepreg of the thermosetting polymer and the thermoplastic polymer, impregnating a layer of reinforcing fibres with the solution thus produced, and curing the thermosetting polymer.

24. A method according to claim 22 or 23, wherein the thermosetting polymer comprises a phenolic resin, a phenol-formaldehyde resin, an amine-formaldehyde

resin, a urea-formaldehyde resin, a polyester resin, a urethane resin, an epoxy resin, an epoxy-polyester resin, an acrylic resin, an acrylic-urethane resin, a fluorovinyl resins; a cyanate ester resin; a polyimide resin or other high temperature thermosetting resin.

25. A method according to any one of claims 22 to 24, wherein the thermosetting polymer is an epoxy resin and the thermoplastic polymer is polybisphenol-A-co-epichlorohydrin.

26. A method according to any one of claims 22 to 25, wherein the thermoplastic polymer does not chemically react with the thermosetting polymer at ambient temperatures.

27. A method according to any one of claims 22 to 26, wherein the thermoplastic polymer is wholly miscible with the thermosetting polymer.

28. A method of producing a self-healing composite material substantially as described in the Examples.

29. A method of producing a self-healing composite material substantially as hereinbefore described.

30. A composite material according to any of one of claims 1 to 21 that has been produced by a method according to any one of claims 22 to 29.

31. A self-healing composite material comprising a fibre-reinforced polymeric matrix, wherein the

polymeric matrix comprises a thermosetting polymer and a thermoplastic polymer, and wherein detection means are provided to detect the presence of at least one damaged area of the composite material.

32. A composite material according to claim 31, wherein detection means are provided to detect the presence and location of at least one damaged area of the composite material.

33. A composite material according to claim 31 or 32, wherein the detection means detects a change in a physical parameter of the composite material caused either directly or indirectly by the damage.

34. A composite material according to any one of claims 31 to 33, wherein the detection means detects a change in acoustic wave propagation or electrical resistance.

35. A composite material according to claim 34, wherein the self-healing composite material is provided with means for generating acoustic waves in the material and means for detecting acoustic waves reflected from a damaged area.

36. A composite material according to claim 35, wherein the acoustic waves are ultrasonic waves.

37. A composite material according to claim 36, wherein

the ultrasonic waves are acousto-ultrasonic guided waves.

38. A composite material according to claim 37, wherein the ultrasonic waves are Lamb waves.

39. A composite material according to any one of claims 35 to 38, wherein the means for generating acoustic waves comprises one or more piezoelectric transducers or actuators.

40. A composite material according to any one of claims 35 to 39, wherein the means for detecting acoustic waves reflected from a damaged area comprises a fibre Bragg grating sensor, or a multi-point laser scanning vibrometer.

41. A composite material according to any one of claims 35 to 39, wherein the means for detecting acoustic waves reflected from a damaged area comprises one or more piezoelectric transducers that can act as both wave propagators and receivers.

42. A composite material according to any one of claims 32 to 34, wherein detection means are provided to detect a change i resistance of the composite material, said change in resistance indicating the presence of at least one damaged area of the composite material.

43. A composite material according to claim 42, wherein the reinforcing fibres comprise carbon fibres and the detection means comprises one or more electrodes in electrical contact with the carbon fibres.

44. A composite material according to claim 43, wherein a plurality of spaced apart electrodes is provided, disposed along one or more edge regions of the composite material.

45. A composite material according to claim 43 or 44, wherein the carbon fibres are aligned axially and the electrodes are connected to opposed ends of the carbon fibres.

46. A composite material according to any one of claims 43 to 45, wherein the composite material comprises a laminate of two or more fibre reinforcing layers, each containing carbon fibres, wherein the carbon fibres of a first layer are aligned at an angle to the carbon fibres of a second layer, and wherein each layer is separately provided with electrodes connected to its carbon fibres.

47. A composite material according to claim 46, wherein the electrodes are connected to a resistance measuring and monitoring means having an output providing an indication of the position of an area of damage.

48. A composite material provided with damage detection means according to any one of claims 31 to 47

substantially as hereinbefore described.

49. A method of detecting the presence of a damaged area in a self-healing composite material comprising a reinforced polymeric matrix, wherein the reinforcement comprises carbon fibres and the polymeric matrix comprises a thermosetting polymer and a thermoplastic polymer, which comprises detecting a change in resistance of the composite material indicating the presence of at least one damaged area.

50. A method according to claim 49, wherein there is used a composite material provided with damage detection means according to any one of claims 42 to 49.

51. A method of detecting the presence of a damaged area in a self-healing composite material substantially as described in the Examples.

52. A method of detecting the presence of a damaged area in a self-healing composite material substantially as hereinbefore described.

53. A method of repairing a damaged area in a self-healing composite material comprising a fibre-reinforced polymeric matrix, wherein the polymeric matrix comprises a thermosetting polymer and a thermoplastic polymer, which comprises heating the damaged area to the fusion temperature of the thermoplastic polymer.

54. A method according to claim 53, wherein there is used a composite material according to any one of claims 1 to 21 and 31 to 48.

55. A method according to claim 53 or 54, wherein the damaged area is heated to a temperature of from the Tg of the thermoplastic polymer to Tg + 75°C.

56. A method according to claim 55, wherein the damaged area is heated to a temperature of from Tg+30°C to Tg+60°C.

57. A method according to any one of claims 53 to 56, wherein the damaged area is heated for a time optimised to give maximum healing.

58. A method according to claim 57, wherein the damaged area is heated for a time of from 5 to 60 minutes.

59. A method according to any one of claims 53 to 58, wherein the composite material comprises carbon fibres and the damaged area is heated by passing a current through the carbon fibres, at least in the damaged area.

60. A method according to any one of claims 53 to 59, wherein the carbon fibres are used both for detection of the damaged area and for heating of the damaged area by resistance heating.

61. A method of repairing a composite material substantially as herein before described.

62. A self-healing polymeric matrix for a composite material which comprises a blend of a thermosetting polymer and a thermoplastic polymer that together form a solid solution.